Ground-Based Diurnal Measurements of NO$_2$ and NO$_3$ in Support of SAGE-III/ISS Validation

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Objectives

Objective 1: Obtain 24 hour measurements of NO$_3$ and NO$_2$ from Table Mountain Facility in support of SAGE III/ISS validation.

Objective 2: Analyze comparisons with coincident SAGE III/ISS measurements and work with the algorithm and science teams to interpret the comparisons and incorporate improvements into retrieval algorithms.

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<td>Stanley P. Sander, JPL/Caltech</td>
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Ground-Based Diurnal Measurements of NO$_2$ and NO$_3$
Direct Solar/Lunar and Sky light Spectroscopy
at JPL Table Mountain Facility (2.3 km ASL)
Issues Confronting Ground-Based Comparisons with SAGE III

• Lower limit of SAGE III vertical profiles is 12-15 km (due to large uncertainty only 17 km and above are used)
• Ground-based occultations extend from 2.3 km to TOA

• SAGE III solar occultations occur at sun rise/set
  • Diurnal Corrections described in Dubè et. al. have been used in this comparison
  • We have implemented an additional measurement capability of zenith sky light to capture rise and set times which allows for a full 24 hour measurement of NO2 (Radiative transfer model used to find zenith sky airmass factors)

• Both SAGE III and ground-based lunar occultations occur over a range of local times
MUGS Comparisons with SAGE-III/ISS

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<th>Latitude Band</th>
<th>Number of Coincidence</th>
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<tbody>
<tr>
<td>NO₂ Sunrise</td>
<td>+/- 1°</td>
<td>333</td>
</tr>
<tr>
<td>NO₂ Sunset</td>
<td>+/- 1°</td>
<td>328</td>
</tr>
<tr>
<td>NO₂ Lunar</td>
<td>+/- 5°</td>
<td>366</td>
</tr>
<tr>
<td>NO₃ Lunar</td>
<td>+/- 5°</td>
<td>366</td>
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(SAGE III/ISS Profile Examples taken from single day from +/- 10°)
• Exact coincidences between SAGE-III and TMF are infrequent
• We consider coincidences within a global zone from TMF latitude(34.4 °N)
  • ± 1° for solar and ± 5° latitude for lunar
• SAGE occultations at other longitudes are converted to TMF local time
Creating an Empirical Model from the Measurements

Acquire Spectra
- Sun
- Sky
- Moon

Differential Slant Column Retrieval Relative to Noon
- Modified Langley Extrapolation accounts for diurnal shape (AMFs calculated)
- Vertical columns only the 20\textsuperscript{th} percentile used to eliminate boundary layer events

Find Diurnal Trends for monthly subsets
- Linear positive
- Normalized Shape
- Linear Negative

Seasonal trends determined from monthly subsets

Use seasonal and diurnal trends to find Empirical Model
Diurnal Variation of NO$_2$ Column: SAGE III and MUGS

Composite of June
13 days from MUGS 2019 to 2022
8 Days from SAGE 2017 to 2022
SAGE-MUGS NO$_2$ Comparison: year-over-year
Scatter plot between SAGE-III partial columns (z>17 km and after diurnal correction) and MUGS total column empirical model

$r^2 = 0.927$
Slope = 0.906
Intercept = $1.71 \times 10^{13}$ cm$^{-2}$
Estimation of partial NO$_2$ column above 17 km
Using the Photochemical Model
SAGE-MUGS NO$_3$ Comparison: year-over-year
SAGE-MUGS NO$_3$ Correlation

$r^2 = 0.488$
Slope = 0.802
Intercept = 1.95x10$^{12}$ cm$^{-2}$
Summary

• TMF total column measurements
  • Effects of PBL pollution, diurnal trends, and seasonal variation have been corrected using the entirety of the MUGS data set

• SAGE-III profile measurements are converted to partial column
  • Diurnally corrected data from Latitude bands surrounding TMF collapsed to local time currently provide 1393 individual profiles to compare

• NO₂ shows excellent correlation between the two data sets with SAGE-III being systematically lower by about 10%. This is almost perfectly accounted for by the photochemical model showing the same amount is below 17 km.

• NO₃ has decent correlation to between the two data sets with SAGE-III being systematically lower by about 20%. Further focus on this to come.

• Future work will extending the ground-based climatologies and diurnal trends, correcting for FT partial column using more comprehensive model analysis, studying the radiative transfer model to improve ground based measurements of sunrise and sunset. Collection of more direct coincidence measurements.